Learning Style and Problem Solving in Technology Education (II)

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The present study examines the problems that occur to the students and their concrete solutions in Technology Education to clarify how students' learning styles would affect their problem solving behaviors. After the class of "Machines" area was taught to the third year students at a junior high school, both the problems that occurred to them and the specific solutions were studied according to the students' learning styles. As a result, it is found that students with each learning style shows the differences in the specific solutions they took. The students with "Versatile and Deep Holist Type" applied solutions of "Enhancing awareness" more than the students with other two types as it was shown in the units of "Leg Production" and "Modification." On the other hand, the students with "Deep Serialist Type" were found that they didn't utilize solutions of "Modeling" as much as other students with other two types. This finding confirms that the "Deep Serialist Type" students have field-independent characteristic.

Key words: Learning Style, Problem Solving, Technology Education

1. Introduction

The previous report[1] examines how students' learning styles[2] affect their fostering problem solving ability. The present study aims to clarify how the difference of students' learning styles would affect their problem solving behaviors. The problems happened to students in each teaching unit and their concrete solutions are examined after all class hours finished according to the students' learning styles.

2. Study Method

In this study, the same class, teaching plan, selection of students for three learning styles are used as the previous report[1]. Students were asked after all class hours finished to describe freely about the problems they encountered during each of the four units of the teaching plan and their concrete solutions to them. Appendix 1 shows the questionnaires that was used for the study.

3. Results and Considerations

The problems occurred to the students can be classified into three categories in this study: "Knowledge-related Problem," "Technological Problem," and "Others." Specific solutions to them are also able to be classified into seven categories: "Different Technological Approach," "Skillful Usage of Tools or Materials," "Repeating," "Modeling," "Enhancing Awareness," "Other Solution," and "No Solution."

3.1 Wiring Unit

Table 1 shows the relations between the problems that students encountered and their concrete solutions in the first unit "Wiring." Taking the problems related with method of wiring as an instance, which are "Knowledge-Related Problems," "Versatile and Deep Holist Type" used "Different Technological Approach" in two cases. On the other hand, "Deep Serialist Type" applied "Skilful Usage of Tools or Materials" and "Modeling" as solutions in two and one cases respectively. "Surface Type" utilized "Different Technological Approach," "Repeating," and "Modeling" in one case each. Concerning the problems related with accuracy of operation, which is "Technological Problems," "Versatile and Deep Holist Type" used "Different Technological Approach" in one case. While "Deep Serialist Type" applied "Different Technological Approach" and "Repeating" in one case each, while "Surface Trype" used "Repeating" in two cases.

Among all problems, the knowledge-related problems occurred in the unit of "Wiring" to the students with "Versatile and Deep Holist Type," "Deep Serialist Type," and "Surface Type" in five, four, and five cases respectively. On the other hand, the technological problems happened to the students with "Versatile and Deep Holist Type," "Deep Serialist Type," and "Surface Type" in seven, four, and five cases respectively. As their concrete solutions, "Different Technological Approach" was used by "Versatile and Deep Holist Type" in five cases, by "Deep Serialist Type" in four cases, and by "Surface

Type" in two cases."Skilful Usage of Tools or Materials" was applied by "Versatile and Deep Holist Type" in three cases. "Repeating" was used by "Versatile and Deep Holist Type" in three cases, by "Deep Serialist Type" in two cases, and by "Surface Type" in five cases. "Modeling" was utilized by "Versatile and Deep Holist Type" in two cases, by "Deep Serialist Type" in one case, and by "Surface Type" in three cases. "Enhancing Awareness" was used by "Versatile and Deep Holist Type" in two cases, and "No Solution" was found in one case by "Deep Serialist Type."

It is considered with these findings that "Deep Serialist Type" and "Surface Type" students tend to

Table 1   Problems and Concrete Solutions in "Wiring" Unit.

Category of Problem		Type	Different Technological Approach	Skilful Usage of Tools or Materials	Repeating	Modeling	Enhancing Awareness	No Solution	Sub - Total	Unit Total
Knowledge - Related Problem	Problems Related with Knowledge and Understanding of Wiring	Versatile and Deep Holist Type	1			1			4	14
		Deep Serialist Type								
		Surface Type			1	1				
	Problems Related with Method of Wiring	Versatile and Deep Holist Type	2						8	
		Deep Serialist Type		2		1				
		Surface Type	1		1	1				
	Problems Related with the Product Movement	Versatile and Deep Holist Type				1			2	
		Deep Serialist Type						1		
		Surface Type								
Technological Problem	Problems Related with Handing Tools and Materials	Versatile and Deep Holist Type	1		3		2		11	16
		Deep Serialist Type		1	1					
		Surface Type	1		1	1				
	Problems Related with Accuracy of Operation	Versatile and Deep Holist Type	1						5	
		Deep Serialist Type	1		1					
		Surface Type			2					
Total			8	3	10	6	2	1	30	30

Category	Type	Different Technological Approach	Skilful Usage of Tools or Materials	Repeating	Modeling	Enhancing Awareness	No Solution	Sub - Total	Total
Knowledge - Related Problem	Versatile and Deep Holist Type	3			2			5	14
	Deep Serialist Type		2		1		1	4	
	Surface Type	1		2	2			5	
Technological Problem	Versatile and Deep Holist Type	2		3		2		7	16
	Deep Serialist Type	1	1	2				4	
	Surface Type	1		3	1			5	
Total by Learning Style	Versatile and Deep Holist Type	5		3	2	2		12	30
	Deep Serialist Type	1	3	2	1		1	8	
	Surface Type	2		5	3			10	

use "Different Technological Approach" and "Repeating" respectively more than other students with different learning styles.

3.2 Leg Mechanism Unit

Table 2 shows the relations between the problems that happened to the students and their concrete solutions in the second unit "Leg Mechanism." Taking the problems on leg length in deciding leg mechanism as an example, which is "Knowledge-Related Problems," "Versatile and Deep Holist Type" used "Modeling" in two cases and "No Solution" was found in one case by this type. While "Deep Serialist Type" applied "Different Technological Approach" in one case, "Surface Type" utilized "Different Technological Approach" and "Modeling" in two and one cases respectively.

Among the problems that occurred to the students with each learning style in the "Leg Mechanism" unit, "Knowledge-Related Problems" happened to the

Table 2 Problems and Concrete Solutions in "Leg Mechanism" Unit.

Category of Problem		Different Technological Approach	Modeling	Enhancing Awareness	No Solution	Sub-Total	Unit Total
Knowledge - Related Problem — Problem Related with Knowledge and Understanding of Leg Mechanism	Versatile and Deep Holist Type		1				
	Deep Serialist Type					2	
	Surface Type	1					
Problem Related with Decision Method of Leg Mechanism	Versatile and Deep Holist Type	1	1	1			
	Deep Serialist Type					4	
	Surface Type	1					20
Problem on Leg Length in Deciding Leg Mechanism	Versatile and Deep Holist Type		2		1		
	Deep Serialist Type	1				7	
	Surface Type	2	1				
Problem on Product Movement in Deciding Leg Mechanism	Versatile and Deep Holist Type	3					
	Deep Serialist Type	2				7	
	Surface Type	1	1				
Other Problem	Versatile and Deep Holist Type						
	Deep Serialist Type				1	1	1
	Surface Type						
Total		12	6	1	2	21	21

Knowledge - Related Problem	Versatile and Deep Holist Type	4	4	1	1	10	
	Deep Serialist Type	3				3	20
	Surface Type	5	2			7	
Other Problem	Versatile and Deep Holist Type						
	Deep Serialist Type				1	1	1
	Surface Type						
Total by Learning Style	Versatile and Deep Holist Type	4	4	1	1	10	
	Deep Serialist Type	3			1	4	21
	Surface Type	5	2			7	

students with "Versatile and Deep Holist Type," "Deep Serialist Type," and "Surface Type" in ten, three, and seven cases respectively. As their concrete solutions, "Different Technological Approach" was used by "Versatile and Deep Holist Type" in four cases, by "Deep Serialist Type" in three cases, and by "Surface Type" in five cases. "Modeling" was applied by "Versatile and Deep Holist Type" and "Surface Type" in four and two cases respectively. "Enhancing Awareness" was used by "Versatile and Deep Holist Type" in one case, and "No Solution" was found also in one case by "Versatile and Deep Holist Type."

These findings show that "Versatile and Deep Holist Type" and "Surface Type" students applied "Modeling" as a solution in the "Leg Mechanism" unit. This confirms the field-dependent characteristic of "Versatile and Deep Holist Type" and the characteristic of "Surface Type," which is modeling other students' learning behaviors.

3.3 Leg Production Unit

Table 3 shows the relations between the problems that students encountered and their concrete solutions in the unit of "Leg Production." Taking the problems related with production method of legs as an instance, which is "Knowledge-Related Problems," "Versatile and Deep Holist Type" used "Different Technological Approach" in one case. While "Deep Serialist Type" applied "Different Technological Approach" in two cases, "Surface Type" utilized "Modeling" in one case. Regarding the problems related with handling tools and materials, which is "Technological Problems," "Versatile and Deep Holist Type" utilized "Enhancing Awareness" in five cases. "Deep Serialist Type" applied "Skilful Usage of Tools or Materials" in one case while "Surface Type" utilized "Different Technological Approach" and "Repeating" in two and one cases respectively.

Among the problems that occurred to the students with each learning style in the "Leg Production" unit, "Knowledge-Related Problems" happened to the students with "Versatile and Deep Holist Type," "Deep Serialist Type," and "Surface Type" in nine, six, and four cases respectively. On the other hand, "Technological Problems" occurred to the students with "Versatile and Deep Holist Type," "Deep Serialist Type," and "Surface Trype" in eight, five, and five cases respectively. As their concrete solutions, "Different Technological Approach" was used by "Versatile and Deep Holist Type" in four cases, by

"Deep Serialist Type" in five cases, and by "Surface Type" in three cases. "Skilful Usage of Tools or Materials" was applied by "Versatile and Deep Holist Type" and "Surface Type" in two and one case respectively. "Modeling" was used by "Versatile and Deep Holist Type" and "Surface Type" in one case each. "Enhancing Awareness" was utilized by "Versatile and Deep Holist Type," "Deep Serialist Type," and "Surface Type" in five, one, and one case respectively. "No Solution" was found in one case by "Surface Type."

These findings show that "Versatile and Deep Holist Type" students were aware of more problems than other students with different learning styles and tend to use "Enhancing Awareness" as a solution. On the other hand, students with "Versatile and Deep Holist Type" and "Surface Type" applied "Modeling" as a solution. This is considered to confirm the field-dependant characteristic of "Versatile and Deep Holist Type" and characteristic of "Surface Type," which is modeling other students' learning behaviors again as the previous unit.

3.4 Modification

Table 4 shows the relations between the problems that happened to the students and their concrete solutions in the unit of "Modification." Taking the problems related with product movement as an example, which is "Knowledge-Related Problems," "Versatile and Deep Holist Type" used "Different Technological Approach," "Skilful Usage of Tools or Materials," "Enhancing Awareness" in two, one, and one case respectively. "No Solution" was also found in one case by this type. "Deep Serialist Type" applied "Different Technological Approach" and "Skilful Usage of Tools or Materials" in three and one case respectively. "Surface Type" utilized "Skilful Usage of Tools or Materials" in one case and "No Solution" was found in one case with this type. Concerning the problems related with handling tools and materials, which is "Technological Problems," "Versatile and Deep Holist Type" utilized "Different Technological Approach," "Skilful Usage of Tools or Materials," "Repeating," and "Enhancing Awareness" in one case each. "Deep Serialist Type" applied "Different Technological Approach," "Skilful Usage of Tools or Materials" in one case each. "Surface Type" used "Different Technological Approach" and "Modeling" in one case each, and "Skilful Usage of Tools or Materials" in two cases.

Among the problems that occurred the students with each learning style encountered in the "Modification" unit, "Knowledge-Related Problems" happened to the students with "Versatile and Deep Holist Type," "Deep Serialist Type," and "Surface Trype" in seven, five, and six cases respectively. On the other hand, "Technological Problems" occurred to the students with "Versatile and Deep Holist Type," "Deep Serialist Type," and "Surface Type" in six, five, and four cases respectively. As their concrete solutions, "Different Technological Approach" was used by "Versatile and Deep Holist Type" in two cases, by "Deep Serialist Type" in two cases, and by "Surface Type" in four cases. "Skilful Usage of Tools or Materials" was applied by "Versatile and Deep Holist Type" in one case, by "Deep Serialist Type" in two cases, and by "Surface Type" in two cases. "Repeating" was utilized by "Versatile and Deep Holist Type" in one cases, by "Deep Serialist Type" in two cases, and by "Surface Type" in two cases.

Table 3   Problems and Concrete Solutions in "Leg Productioon" Unit.

Category of Problem		Learning Style	Different Technological Approach	Skilful Usage of Tools or Materials	Repeating	Modeling	Enhancing Awareness	No Solution	Other Solution	Sub-Total	Unit Total
Knowledge - Related	Problems Related with Production Method of Legs	Versatile and Deep Holist Type	1							4	19
		Deep Serialist Type	2								
		Surface Type				1					
	Problems Related with the Product Movement	Versatile and Deep Holist Type	3	1	4					15	
		Deep Serialist Type	2		1		1				
		Surface Type	2					1			
Technological Problem	Problems Related with Handing Tools and Materials	Versatile and Deep Holist Type					5			8	18
		Deep Serialist Type		1							
		Surface Type	1	1							
	Problems Related with Operational Accuracy	Versatile and Deep Holist Type		1	1	1				8	
		Deep Serialist Type	1		3						
		Surface Type			1						
	Problems Related with Operational Advancement	Versatile and Deep Holist Type								2	
		Deep Serialist Type									
		Surface Type						1	1		
Other Problem		Versatile and Deep Holist Type								1	1
		Deep Serialist Type									
		Surface Type			1						
Total			12	3	12	2	7	1	1	38	38

Category of Problem	Learning Style	Different Technological Approach	Skilful Usage of Tools or Materials	Repeating	Modeling	Enhancing Awareness	No Solution	Other Solution	Sub-Total	Unit Total
Knowledge - Related Problem	Versatile and Deep Holist Type	4	1	4					9	19
	Deep Serialist Type	4		1		1			6	
	Surface Type	2			1		1		4	
Technological Problem	Versatile and Deep Holist Type		1	1	1	5			8	18
	Deep Serialist Type	1	1	3					5	
	Surface Type	1		2		1		1	5	
Other Problem	Versatile and Deep Holist Type									1
	Deep Serialist Type									
	Surface Type			1					1	
Total by Learning Style	Versatile and Deep Holist Type	4	2	5	1	5			17	38
	Deep Serialist Type	5	1	4		1			11	
	Surface Type	3		2	1	1	1	1	9	

Table 4 Problems and Concrete Solutions in "Modification" Unit.

Category of Problem		Category of Solution	Different Technological Approach	Skillful Usage of Tools or Materials	Repeating	Modeling	Enhancing Awareness	No Solution	Other Solution	Sub-Total	Unit Total
Knowledge - Related Problem	Problems Related with Modification Method	Versatile and Deep Holist Type					1				
		Deep Serialist Type								1	
		Surface Type									
	Problems Related with Finding Modification Points	Versatile and Deep Holist Type	1								
		Deep Serialist Type			1					4	
		Surface Type	1		1						18
	Problems Related with the Length of the Product's Leg	Versatile and Deep Holist Type									
		Deep Serialist Type								2	
		Surface Type		1	1						
	Problems Related with Product Movement	Versatile and Deep Holist Type	2	1			1	1			
		Deep Serialist Type	3	1						11	
		Surface Type		1				1			
Technological Problem	Problems Related with Handling Tools and Materials	Versatile and Deep Holist Type	1	1	1		1				
		Deep Serialist Type	3	1	1					13	
		Surface Type	1	2		1					
	Problems Related with Operational Accuracy	Versatile and Deep Holist Type	1								
		Deep Serialist Type								1	15
		Surface Type									
	Problems Related with Operational Advancement	Versatile and Deep Holist Type					1				
		Deep Serialist Type								1	
		Surface Type									
Other Problem		Versatile and Deep Holist Type						1	1		
		Deep Serialist Type								2	2
		Surface Type									
Total			**13**	**8**	**5**	**1**	**4**	**3**	**1**	**35**	**35**

			Different Technological Approach	Skillful Usage of Tools or Materials	Repeating	Modeling	Enhancing Awareness	No Solution	Other Solution	Sub-Total	Unit Total
Knowledge - Related Problem		Versatile and Deep Holist Type	3	1			2	1		7	
		Deep Serialist Type	3	1	1					5	18
		Surface Type	1	2	2			1		6	
Technological Problem		Versatile and Deep Holist Type	2	1	1		2			6	
		Deep Serialist Type	3	1	1					5	15
		Surface Type	1	2		1				4	
Other Problem		Versatile and Deep Holist Type						1	1	2	
		Deep Serialist Type									2
		Surface Type									
Total by Learning Style		Versatile and Deep Holist Type	5	2	1		4	2	1	15	
		Deep Serialist Type	6	2	2					10	35
		Surface Type	2	4	2	1		1		10	

"Modeling" was used by "Surface Type" in one case while "Enhancing Awareness" was utilized by "Versatile and Deep Holist Type" in four cases. "No Solution" was found in one case each by "Versatile and Deep Holist Type" and "Surface Type."

These findings show that "Versatile and Deep Holist Type" students tend to use "Different Technological Approach" and "Enhancing Awareness" and "Deep Serialist Type" students tend to use "Different Technological Approach" as a solution more than other students with different leaning styles in the unit of "Modification." In addition, it can be considered that the characteristic of "Surface Type," which is modeling other students' learning behavior, is confirmed by the finding that "Surface Type" students used "Modeling" as a solution again.

3.5 Through All Units

Concerning the whole units, Table 5 shows the relations between the problems that happened to the students and their methods of specific solutions according to their learning styles. Among all problems, "Knowledge-related Problems" were found in 31 cases with "Versatile and Deep Holist Type," in 18 cases with "Deep Serialist Type," and in 21 cases with "Surface Type." On the other hand, "Technological Problems" were found in 21 cases with "Versatile and Deep Holist Type," in 14 cases with "Deep Serialist Type," and in 15 cases with "Surface Type." Among concrete solutions, "Different Technological Approach" was used in 18 cases by "Versatile and Deep Holist Type," in 15 cases by "Deep Serialist Type," and in 12 cases by "Surface Type." "Skillful Usage of Tools or Materials" was applied in four cases by "Versatile and Deep Holist Type," in six cases by "Deep Serialist Type," and in four cases by "Surface Type." "Repeating" was utilized in nine cases by "Versatile and Deep Holist Type," in eight cases by "Deep Serialist Type," and ten "Surface Type." "Modeling" was used in seven cases by "Versatile and

Table 4　Problems and Concrete Solutions in "Modification" Unit.

Category of Problem		Different Technological Approach	Skillful Usage of Tools or Materials	Repeating	Modeling	Enhancing Awareness	No Solution	Other Solution	Sub - Total	Unit Total
Knowledge - Related Problem	Versatile and Deep Holist Type	14	2	4	6	3	2		31	
	Deep Serialist Type	10	3	2	1	1	1		18	70
	Surface Type	8	2	4	5		2		21	
Technological Problem	Versatile and Deep Holist Type	4	2	5	1	9			21	
	Deep Serialist Type	5	3	6					14	50
	Surface Type	4	2	5	2	1		1	15	
Other Problem	Versatile and Deep Holist Type						1	1	2	
	Deep Serialist Type							1	1	4
	Surface Type			1					1	
Total by Learning Style	Versatile and Deep Holist Type	18	4	9	7	12	3	1	54	
	Deep Serialist Type	15	6	8	1	1	1	1	33	124
	Surface Type	12	4	10	7	1	2	1	37	
Total		45	14	27	15	14	6	3	124	124

Deep Holist Type," in one case by "Deep Serialist Type," and in seven cases by "Surface Type." "Enhancing Awareness" was applied in 12 cases by "Versatile and Deep Holist Type," in one case each by "Deep Serialist Type" and "Surface Type."

Chi-square Test was conducted to examine if there were significant differences among students' learning styles concerning the number of concrete solutions to the problems that students encountered. The result shows that the bias of the number of concrete solutions in each learning style is found to be significant at 5% level ($\chi^2(10)=19, 37$). Also, the result of Residual Analysis shows that "Enhancing Awareness" is used by "Versatile and Deep Holist Type" students significantly more at an 1% level, and it is used by "Deep Serialist Type" and "Surface Type" students significantly less at 5% and 10% level respectively. The Residual Analysis also shows that "Modeling" is used by "Deep Serialist Type" students significantly less at 10 % level.

It is found with these results that "Versatile and Deep Holist Type" students use "Enhancing Awareness" as a method of solution more often than other two type students, and "Deep Serialist Type" students use "Modeling" less than other students with different learning styles throughout the whole teaching units.

4. Conclusion

This study examined the problems that students encouter and their concrete solutions in Technology Education classes to clarify how students learning styles are related with them. The result shows the following four characteristics related with students' learning styles. First, most problems happened to "Versatile and Deep Holist Type" students and most solutions were made by the same type students. Second, "Versatile and Deep Holist Type" and "Deep Serialist Type" students use "Different Technological Approach" more than other solutions. Third, "Versatile and Deep Holist Type" students use "Enhancement Awareness" more than other solutions. Fourth, "Deep Serialist Type" students use "Modeling" less than other solutions because they are field-independent. These findings indicate the characteristics of students' learning styles. Therefore, students' learning styles are considered to have deep relations with their problem solving behaviors for learning contents in Technology Education classes.

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＊: a graduate student of Master program from 1999 to 2001

Appendix 1   Problem-Sloving Ability Evaluation Test.

Let's look back the today's lesson.

Date _____

Class _____ Name _____

Please look back the today's lesson and choose one answer for each question that applies most for you.

        A: It holds sufficiently true.
        B: It holds rather true.
        C: It does not hold true to some extent.
        D: It does not hold true completely.

1. I worked on the today's lesson with my own idea.

                                                A   B   C   D

2. I did everything I could do to get the result that satisfied me in the today's lesson.

        A   B   C   D

3. I was surprised, got interested, or wanted to examine very much in the today's lesson.

        A   B   C   D

4. I could think of a lot of good ideas to solve the today's task.

        A   B   C   D

5. I made a judgment properly by myself and did satisfactory learning.

        A   B   C   D

6. I could grasp the structure of the task clearly by myself.

        A   B   C   D

7. I could work on the today's lesson willingly with my own view.

        A   B   C   D

8. I could collect information required for the learning object in the today's lesson.

        A   B   C   D

9. I could use tools properly and worked precisely.

        A   B   C   D

10. Please write what made an impression on you in the today's lesson.

_____

_____

_____